van Dijk, T.A. and Kintsch, W.:*STRATEGIES OF DISCOURSE COMPREHENSION*. Academic Press, New York, 1983.

Young, S. A theory and simulation of macrostructure. Technical Report No. 134, Institute of Cognitive Science, Colorado, 1984.

Walker, H.W. & KIntsch, W. Automatic and strategic aspects of knowledge retrieval. Cognitive Science, 1985, 9, 261-283.

National AIM Project: MENTOR -- MEDICAL EVALUATION OF THERAPEUTIC ORDERS

Principal Investigators: Stuart Speedie, Ph.D. (SPEEDIE@SUMEX-AIM)
School of Pharmacy
University of Maryland
20 N. Pine Street
Baltimore, Maryland 21201
(301) 528-7650

Terrence F. Blaschke, M.D. (BLASCHKE@SUMEX-AIM)
Department of Medicine
Division of Clinical Pharmacology
Stanford University Medical Center
Stanford, California 94305

The goal of the MENTOR project is to implement and begin evaluation of a computer-based methodology for reducing therapeutic misadventures. The project will use principles of artificial intelligence to create an on-line expert system to continuously monitor the drug therapy of individual patients and generate specific warnings of potential and/or actual unintended effects of therapy. The appropriate patient information will be automatically acquired through interfaces to a hospital information system. This data will be monitored by a system that is capable of employing complex chains of reasoning to evaluate therapeutic decisions and arrive at valid conclusions in the context of all information available on the patient. The results reached by the system will be fed back to the responsible physicians to assist future decision making.

Specific objectives of this proposal include:

1. Implement a prototype computer-based expert system to continuously monitor in-patient drug therapy. It will use a modular medical knowledge base and a separate inference engine to apply the knowledge to specific situations.

2. Select a small number of important and frequently occurring drug therapy problems that can lead to therapeutic misadventures and construct a comprehensive knowledge base necessary to detect these situations.

3. Design and begin implementation of an evaluation of the prototype MENTOR system with respect to its impact on the on the physicians' therapeutic decision making as well as its effects on the patient in terms of specific mortality and morbidity measures.

The work in the proposed project will build on the extensive previous work in drug monitoring done by these investigators in the Division of Clinical Pharmacology at Stanford and the University of Maryland School of Pharmacy.

Rutgers AIM Project: RUTGERS RESEARCH RESOURCE-COMPUTERS IN BIOMEDICINE

Principal Investigators: Casimir Kulikowski, Ph.D.
Sholom M. Weiss, Ph.D
Department of Computer Science
Rutgers University
New Brunswick, New Jersey 08903
(201) 932-2006 (KULIKOWSKI@RUTGERS)
(201) 932-2379 (WEISS@RUTGERS)

The Rutgers Research Resource provides the research support with artificial intelligence systems, and the computing support with its DEC2060 facility to a large number of biomedical scientists and researchers. Research activities are concentrated in two major areas: expert medical systems, models for planning and knowledge acquisition, and general AI systems development.

One of the most significant achievements in bringing the work of the Resource to bear on clinical research and practice lies in the transfer of technology from our large DEC20 machine to microprocessor compatible representations. The initial breakthrough came with the automatic translation of a serum protein electrophoresis interpretation model so that a version could be incorporated in an instrument - a scanning densitometer. It is now being used at several hundred clinical locations.

During the current period, we have been working on a new project with long term implications for the impact of AIM technology: the development of a hand-held microcomputer version of an expert consultation system for front-line health workers. In collaboration with Dr. Chandler Dawson (UCSF), Director of the World Health Organization's Collaborative Centre for the Prevention of Blindness and Trachoma, we have developed a prototype model for consultation on primary eye care. This has been oriented at problems of injury, infection, malnutrition and cataract in situations where an ophthamologist is unavailable. In most developing nations, the incidence of blindness is 10% to 40% higher than in the USA because of these kinds of problems. With the help of a grant from the USAID, we are developing the systems needed for management of eye disease by front-line health workers in developing nations, and outlying parts of the USA.

REFERENCES

Weiss, S.M. and Kulikowski, C.A. *A Practical Guide to Designing Expert Systems*, Rowman and Allanheld, 1984.

Kulikowski, C.A.*Expert Medical Consultation Systems*, Journal of Medical Systems, v.7, pp. 229-234, 1983.*

Weiss, S.M., Kulikowski, C.A., and Galen, R.S.,*Representing Expertise in a Computer Program: The Serum Protein Diagnostic Program*, Journal of Clinical Laboratory Automation, v.3, pp. 383-387, 1983.*

Kastner, J., Dawson, C., Weiss, S., Kern, K., Kulikowski, C., *An Expert Consultation System for Frontline Health Workers in Primary Eye Care*, Journal of Medical Systems, Vol. 8, No. 5 (1984).*

National AIM Project: SECS -- SIMULATION AND EVALUATION OF CHEMICAL SYNTHESIS

Principal Investigator: W. Todd Wipke, Ph.D.
Department of Chemistry
University of California at Santa Cruz
Santa Cruz, California 95064
(408) 429-2397 (WIPKE@SUMEX-AIM)

The SECS Project aims at developing practical computer programs to assist investigators in designing syntheses of complex organic molecules of biological interest. Key features of this research include the use of computer graphics to allow chemist and computer to work efficiently as a team, the development of knowledge bases of chemical reactions, and the formation of plans to reduce the search for solutions. SECS is being used by the pharmaceutical industry for designing syntheses of drugs.

A spin-off project, XENO, is aimed at predicting the plausible metabolites of foreign compounds for carcinogenicity studies. First, the metabolism is simulated; then the metabolites are evaluated for possible carcinogenicity.

SOFTWARE AVAILABLE ON SUMEX

No software is available on SUMEX after 31 March 1985 when this project left the SUMEX system. Contact Dr. Wipke directly.

REFERENCES

Wipke, W.T., Rogers, D.: *Rapid Subgraph Search Using Parallelism.* J. Chem. If. Comput. Sci., 24:4 255-262 (1984).

Wipke, W.T.: "An Integrated System for Drug Design" in *The Aster Guide to Computer Applications in the Pharmaceutical Industry* Aster Publishing Co., Springfield, Oregon, 1984, pp 149-166.

Wipke, W.T., and Rogers, D.: *Artificial Intelligence in Organic Synthesis. SST: Starting Material Selection Strategies. An Application of Superstructure Search.* J. Chem. Inf. Comput. Sci., 24:1 71-81, 1984.

Wipke, W.T.: *Computer Modeling in Research and Development*, Cosmetics and Toiletries, 99:Oct 73-82 (1984).

Wipke, W.T.: *Computer-Assisted Design of Organic Synthesis. ALCHEM: A Language for Representing Chemical Knowledge*, J. Chem. Info. Comput. Sci., 24, 0000 (1985).

National AIM Project: SOLVER -- PROBLEM SOLVING EXPERTISE

Principal Investigators: Paul E. Johnson, Ph.D., School of
Management and
Center for Research in Human Learning
205 Elliott Hall
University of Minnesota
Minneapolis, Minnesota 55455
(612) 376-2530 (PJOHNSON@SUMEX-AIM)

William B. Thompson, Ph.D.
Department of Computer Science
136 Lind Hall
University of Minnesota
Minneapolis, Minnesota 55455
(612) 373-0132 (THOMPSON@SUMEX-AIM)

The Minnesota SOLVER project focuses upon the development of strategies for discovering and representing the knowledge and skill of expert problem solvers. Although in the last 15 years considerable progress has been made in synthesizing the expertise required for solving complex problems, most expert systems embody only a limited amount of expertise. What is still lacking is a theoretical framework capable of reducing dependence upon the expert's intuition or on the near exhaustive testing of possible organizations. Our methodology consists of: (1) extensive use of verbal thinking aloud protocols as a source of information from which to make inferences about underlying knowledge structures and processes; (2) development of computer models as a means of testing the adequacy of inferences derived from protocol studies; (3) testing and refinement of the cognitive models based upon the study of human and model performance in experimental settings. Currently, we are investigating problem-solving expertise in domains of medicine, financial auditing, management, and law.

SOFTWARE AVAILABLE ON SUMEX

A redesigned version of the Diagnoser simulation model, named Galen, has been implemented on SUMEX.

REFERENCES

Johnson, P.E., Moen, J.B., and Thompson, W.B.: *Garden Path Errors in Medical Diagnosis.* IN Bloc, L. and Coombs, M.J. (Eds.), COMPUTER EXPERT SYSTEMS, Springer-Verlag (in press).

Johnson, P.E., Johnson, M.G., and Little, R.K.: *Expertise in trial advocacy: Some considerations for inquiry into its nature and development*, Campbell Law Review, (in press).

Johnson, P.E., "The Expert Mind: A New Challenge for the Information scientist," in *Beyond Productivity: Information System Development for Organizational Effectiveness*, Th. M. A. Bemelmans (editor), Elsevier Science Publishers B. V. (North-Holland), 1984.

Johnson, P.E.: *What kind of expert should a system be?* J. Medicine and Philosophy, 8:77-97, 1983.

Johnson, P.E., Duran, A., Hassebrock, F., Moller, J., Prietula, M., Feltovich, P. and Swanson, D.: *Expertise and error in diagnostic*

reasoning. Cognitive Science 5:235-283, 1981.

Thompson, W.B., Johnson, P.E. and Moen, J.B.: *Recognition-based diagnostic reasoning*. Proc. Eighth IJCAI, Karlsruhe, West Germany, August, 1983.

Stanford Pilot Project: THE COMPUTER-AIDED MEDICAL DECISION ANALYSIS (CAMDA) PROJECT

Co-Principal Investigator: Samuel Holtzman
Ronald A. Howard
Department of Engineering-Economic Systems
Stanford University
Stanford, California 94305

Contact: Samuel Holtzman(HOLTZMAN@SUMEX-AIM)
(415) 497-0486

The CAMDA project is a program of research in the area of medical decision making. The main focus of this effort is to combine decision analysis and artificial intelligence to develop systems that support medical decisions.

Nearly two decades of experience in the application of decision analysis to problems in industry and government have shown that the technique constitutes an extremely helpful tool for making difficult choices. The potential benefit of decision analysis is particularly great when choices must be made in the presence of uncertainty and when the stakes involved are high. This situation is common in medical decisions.

Partly as a result of the high cost of an individual decision analysis, and partly due to the inherent complexity of making choices which involve outcomes such as pain and death, medical decision analysis has remained essentially within the realm of the academic community. Therefore, the majority of patients and physicians have been deprived of the benefits of this powerful technique.

Expert system technology makes it possible to bring decision analysis to the medical community in general. By providing a sophisticated modeling methodology, expert systems allow the process of decision analysis (within a specific medical context) to be formalized with sufficient accuracy to make much of the analysis amenable to computer automation. The resulting CAMDA systems could provide an attractive alternative to unaided decision making, and to the usually unaffordable option of analyzing medical decisions individually. Furthermore, these systems can help decision makers think more clearly about the difficult issues they face by providing them with a means to experiment with the logical consequences of their assumptions and preferences.

A major focus of our research effort is the development of RACHEL, an intelligent decision system for infertile couples. The field of infertility was chosen for several reasons, including the prevalence of the condition, the complexity of the values that are usually attached to the possible outcomes in this field, the rapidly growing set of available tests and treatments, and the time-dependent nature of the human reproductive process.

As part of the development of RACHEL, a substantial portion of the current CAMDA effort is aimed at the development of a general computer-based aid for medical decision analysis, which could be used in other medical decision domains.

REFERENCES:

Holtzman, S.: *A Decision Aid for Patients with End-Stage Renal Disease*, Department of Engineering-Economic Systems, Stanford University, Stanford, California, 1983.

Holtzman, S.:*On the Use of Formal Methods for Decision Making*, Department of Engineering-Economic Systems, Stanford University, 1985.

(*) Holtzman, S.:*Intelligent Decision Systems*, Ph.D. Dissertation, Department of Engineering-Economic Systems, Stanford University, 1985.

Stanford Project: REFEREE Project

Principal Investigators: Bruce G. Buchanan, Ph.D. (BUCHANAN@SUMEX-AIM)
Computer Science Department
701 Welch Road
Stanford University
Palo Alto, California 94304
(415) 497-0935

Byron W. Brown (BWROWN@SUMEX-AIM)
Department of Biostatistics
Stanford University Medical Center
Stanford, California 94305

Daniel E. Feldman (DFELDMAN@SUMEX-AIM)
Department of Medicine
Stanford University Medical Center
Stanford, California 94305

COLLABORATIVE PROJECT ABSTRACT

The goal of this project is two-fold: (a) use existing AI methods to implement an expert system that can critique medical journal articles on clinical trials, and (b) in the long term, develop new AI methods that extract new medical knowledge from the clinical trials literature. In order to accomplish (a) we are building the system in three stages.

1. System I will assist in the evaluation of the quality of a single clinical trial. The user will be imagined to be the editor of a journal reviewing a manuscript for publication, but the program will be tested on a variety of readers, including clinicians, medical scientists, medical and graduate students, and clerical help.

2. System II will assist in the evaluation of the effectiveness of the treatment or intervention examined in a single published clinical trial. The user will be imagined to be a clinician interested in judging the efficacy of the treatment being tested in the trial.

3. System III will assist in the evaluation of the effectiveness of a single treatment examined in a number of published clinical trials.

National AIM Project: Computer-Aided Diagnosis of Malignant Lymph Node Diseases (PATHFINDER)

Principal Investigator: Bharat Nathwani, M.D.
Department of Pathology
HMR 204
2025 Zonal Avenue
University of Southern California
School of Medicine
Los Angeles, California 90033
(213) 226-7064 (NATHWANI@SUMEX-AIM)

Lawrence M. Fagan, M.D., Ph.D.
Department of Medicine
Stanford University Medical Center - Room TC135
Stanford, California 94305
(415) 497-6979 (FAGAN@SUMEX-AIM)

We are building a computer program, called PATHFINDER, to assist in the diagnosis of lymph node pathology. The project is based at the University of Southern California in collaboration with the Stanford University Medical Computer Science Group. A pilot version of the program provides diagnostic advice on 80 common benign and malignant diseases of the lymph node based on 150 histologic features. Our research plans are to develop a full-scale version of the computer program by substantially increasing the quantity and quality of knowledge and to develop techniques for knowledge representation and manipulation appropriate to this application area. The design of the program has been strongly influenced by the INTERNIST/CADUCEUS program developed on the SUMEX resource.

SOFTWARE AVAILABLE ON SUMEX

PATHFINDER-- A version of the PATHFINDER program is available for experimentation on the DEC 2060 computer. This version is a pilot version of the program, and therefore has not been completely tested.

References

1. Barr, Avron, Paul R. Cohen and Edward A. Feigenbaum. *The Handbook of Artificial Intelligence, Volumes I, II, and III.* William Kaufmann, Inc., Los Altos, CA, 1981 and 1982.

2. Bennett, James S. and Robert S. Engelmore. "SACON: A Knowledge-Based Consultant for Structural Analysis." *IJCAI Proceedings 6* (1979), 47 - 49.

3. Bryson, Y.J., Dillon, M., Lovett, M., et al. "Treatment of first episodes of genital herpes simplex infection with oral acyclovir." *New England Journal of Medicine 308* (1983), 916-921.

4. Buchanan, B.G., and Shortliffe, E.H.. *Rule-Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project.* Addison-Wesley Publishing Company, Reading, MA, 1984.

5. Coulter, C. L. "Research Instrument Sharing." *Science 201,* 4354 (1978).

6. Emerson, J.D., Graham, A.C. "Use of statistical analysis in the New England Journal of Medicine." *New England Journal of Medicine 309* (1983), 1332-1337.

7. Erman, L.D., Hayes-Roth, F., Lesser, V.R., and Reddy, D.R. "The Hearsay-II speech-understanding system: Integrating knowledge to resolve uncertainty." *Computing Surveys 12* (1980), 213-253.

8. Feinstein, A.R., Horwitz, R.I., Spitzer, W.O., Battista, R.N. "Coffee and Pancreatic Cancer." *JAMA 246* (1981), 957-961.

9. Genesereth, M.R. A Meta-Level Representation System. Tech. Rept. HPP83-28, Stanford University, Knowledge Systems Laboratory, 1983. The Report Consists of Four: HPP80-24, HPP82-27, HPP83-26, and HPP84-1

10. Haggerty, J. REFEREE and RULECRITIC: Two prototypes for assessing the quality of a medical paper. Master Th., Stanford University, 1984.

11. Hart, P.O., Duda, R.O., Einaudi, M.T. "PROSPECTOR -- A Computer-based Consultation System for Mineral Exploration." *Mathematical Geology 10,* 5 (1978).

12. Hayes-Roth, B. The blackboard architecture: A general framework for problem-solving? Tech. Rept. HPP-83-30, Stanford, Ca.: Stanford University, 1983.

13. Hayes-Roth, B. BB1: An architecture for blackboard systems that control, explain, and learn about their own behavior. Tech. Rept. HPP-84-16, Stanford, Ca.: Stanford University, 1984.

14. Hayes-Roth, B. "A blackboard architecture for control." *Artificial Intelligence Journal in press* (1985).

15. Hayes-Roth, F., Waterman, D. A. & Lenat, D. B. (Eds.). *Building Expert Systems.* Addison-Wesley, Reading, MA, 1983.

16. Jardetzky, O. A Method for the Definition of the Solution Structure of Proteins from NMR and Other Physical Measurements: The LAC-Repressor Headpiece. Proceedings of the International Conference on the Frontiers of Biochemistry and Molecular Biology, Alma Alta, June 17-14, 1984, 1984.

17. Kunz, J.C., Fallat, R.J., McClung, D.H., Osborn, J.J., Votteri, B.A., Nii, H.P., Aikins, J.S., Fagan, L.M., Feigenbaum, E.A. A physiological rule-based system for interpreting pulmonary function test results. Proceedings of Computers in Critical Care and Pulmonary Medicine, 1979, pp. 375-379.

18. Keith A. Lantz et. al. *V - System 4.1 Reference Manual.* December 1, 1983. Computer Systems Laboratory, Stanford University.

19. Lederberg, J. "Digital Communications and the Conduct of Science: The New Literacy." *Proceedings of the IEEE 66*, 11 (1978).

20. Levy, R.I. "Current status of cholesterol controversy." *Am J Med 74* (1983), 1-4.

21. Lindsay, R. K., Buchanan, B. G., Feigenbaum, E. A., and Lederberg, J.. *Applications of Artificial Intelligence for Organic Chemistry: The DENDRAL Project.* McGraw-Hill, New York, 1980.

22. MacMahon, B., Yen, S., Trichopoulos, D., et al. "Coffee and cancer of the pancreas." *New England Journal of Medicine 304* (1981), 630-633.

23. Masinter, Larry M. Interlisp VAX: A Report. Tech. Rept. HPP-81-14 or STAN-CS-81-879, Heuristic Programming Project, Stanford University, 1981.

24. McDermott, J. "R1: A rule-based configurer of computer systems." *Artificial Intelligence 9*, 1 (1982), 39-88.

25. Nii, H.P. and Aiello, N. AGE: A Knowledge-based Program for Building Knowledge-based Programs. Proceedings of IJCAI 6, 1979, pp. 645-655.

26. Nilsson, N.. *Principles of Artificial Intelligence.* Tioga, Palo Alto, CA, 1980.

27. Novak, Gorden. *GLISP User's Manual.* Heuristic Programming Project, Stanford University, Stanford Ca. 94305, 1982.

28. Price, D.S. The development and structure of the biomedical literature. In *Coping with the Biomedical Literature*, Praeger, New York, 1981.

29. Rich, E.. *Artificial Intelligence.* McGraw-Hill, New York, 1983.

30. Rout, L. "Fast medical advances give doctors troubles in staying up to date." *Wall Street Journal 104* (1981), 1, 15.

31. Sackett, D.L. "How to read clinical journals: I. Why to read them and how to start reading them critically." *Can Med Assoc J 124* (1981), 555-558.

32. Shortliffe, Edward H.. *Computer-Based Medical Consultation: MYCIN.* American Elsevier, New York, 1976.

33. Smith, Reid G., and Friedland, Peter. Unit Package User's Guide. Tech. Rept. KSL-80-28, Knowledge Systems Laboratory, Stanford University, December, 1980.

34. Van Melle, W., Scott, A.C., Bennett, J.S., and Peairs, M.A.S. The EMYCIN Manual. Tech. Rept. KSL-80-11, Knowledge Systems Laboratory, Stanford University, 1980. Superseded by KSL-81-16

35. Winston, P.. *Artificial Intelligence, 2nd ed.* Addison-Wesley, Reading, MA, 1984.